

When D50 is equal to or more than $0.3\ \mu\text{m}$, the barrier rib material supplied in the form of a paste can be easily and rheologically controlled.

When D50 is less than or equal to $6\ \mu\text{m}$, the resulting barrier rib becomes dense.

When Dmax is equal to or more than $5\ \mu\text{m}$, the barrier rib material supplied in the form of a paste can be easily and rheologically controlled.

When Dmax is less than or equal to $20\ \mu\text{m}$, the resulting barrier rib becomes dense, and the material paste becomes resistant to separation.

The barrier rib material of the present invention comprises the filler powder and glass powder. Such glass powder for use in the present invention is not specifically limited as long as it has a thermal expansion coefficient of from $60 \times 10^{-7}/^{\circ}\text{C}$ to $90 \times 10^{-7}/^{\circ}\text{C}$ (at temperatures ranging from 30°C to 300°C), a dielectric constant of less than or equal to 12.0 at 25°C at 1 MHz and a softening point of from 480°C to 630°C .

Preferred glass powders are powders of a $\text{PbO-B}_2\text{O}_3\text{-SiO}_2$ glass, a $\text{BaO-ZnO-B}_2\text{O}_3\text{-SiO}_2$ glass and a $\text{ZnO-Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-SiO}_2$ glass.

The $\text{PbO-B}_2\text{O}_3\text{-SiO}_2$ glass preferably comprises from 35% to 75% by mass of PbO, from 0% to 50% by mass of B_2O_3 , from 8% to 30% by mass of SiO_2 , from 0% to 10% by mass of Al_2O_3 , from 0% to 10% by mass of ZnO, from 0% to 10% by mass of at least one of CaO, MgO, SrO and BaO and from 0% to 6% by mass of at least one of SnO_2 , TiO_2 and ZrO_2 .

The $\text{BaO-ZnO-B}_2\text{O}_3\text{-SiO}_2$ glass preferably comprises from 20% to 50% by mass of BaO, from 25% to 50% by mass of ZnO, from 10% to 35% by mass of B_2O_3 and from 0% to 10% by mass of SiO_2 .

The $\text{ZnO-Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-SiO}_2$ glass preferably comprises from 25% to 45% by mass of ZnO, from 15% to 40% by mass of Bi_2O_3 , from 10% to 30% by mass of B_2O_3 , from 0.5% to 10% by mass of SiO_2 and from 0% to 24% by mass of at least one of CaO, MgO, SrO and BaO.

The glass powder should preferably have a 50%-point of cumulative particle size distribution (D50) of from 1 to 7 μm and a maximum particle diameter (Dmax) of from 5 to 30 μm . When D50 is equal to or more than 1 μm and Dmax is equal to or more than 5 μm , the barrier rib can satisfactorily maintain its configuration.

When D50 is less than or equal to 7 μm and Dmax is less than or equal to 30 μm , the barrier rib material has an improved sinterability, thereby readily obtaining a dense barrier rib.

The mass ratio of the glass powder to the filler powder in the barrier rib material is preferably from 65:35 to 85:15. When the mass ratio is less than or equal to 85:15, the barrier rib material becomes less flowable during the curing operation and thereby the configuration of the resulting barrier rib is easily maintained.

When the mass ratio is equal to or more than 65:35, the barrier rib material has an improved sinterability, thus easily forming a dense barrier rib.

By using the barrier rib material of the present invention having the above configuration, a barrier rib having a dielectric constant of less than or equal to 10.0, a thermal expansion coefficient of from $60 \times 10^{-7}/^{\circ}\text{C}$ to $85 \times 10^{-7}/^{\circ}\text{C}$ (at temperatures ranging from 30°C to 300°C) and sufficient mechanical strength for practical application can be formed.

The barrier rib material of the present invention can be used in the following manner, for example, in the form of a paste or green sheet.

When the barrier rib material is used in the form of a paste, the paste may comprise a thermoplastic resin, a plasticizer, a solvent or medium, and other additives in addition to the glass powder and the filler powder. The total content of the glass powder and the filler powder in the paste is generally from about 30% to about 90% by mass.

The thermoplastic resin serves to improve the strength of a dried film of the paste and to impart plasticity or flexibility thereto. The content of the thermoplastic resin in the paste is generally from about 0.1% to about 20% by mass. Such thermoplastic resin includes, but is not limited to, poly(butyl methacrylate), polyvinyl butyral, poly(methyl methacrylate), poly(ethyl methacrylate), and ethyl cellulose. The thermoplastic resin can be used alone or in combination.

The plasticizer serves to control the drying rate and to impart plasticity or flexibility to a dried film of the paste. The content of the plasticizer in the paste is generally from about 0% to about 10% by mass. Such plasticizer includes, but is not limited to, butyl benzyl phthalate, dioctyl phthalate, diisooctyl phthalate, dicapryl phthalate [di(2-octyl) phthalate], and dibutyl phthalate. The plasticizer can be used alone or in combination.

The solvent serves to convert the barrier rib material into a paste. The content of the solvent in the paste is generally from about 10% to about 30% by mass. Such solvent includes, but is not limited to, terpeneol, diethylene glycol monobutyl ether acetate, and 2,2,4-trimethyl-1,3-pentanediol monoisobutylate. The solvent can be used alone or in combination.

The paste can be produced by preparing the glass powder, filler powder, thermoplastic resin, plasticizer, solvent, and where necessary, other additional components, and kneading these components in predetermined compositional ratios.

The barrier rib can be formed by using the barrier rib material in the form of such a paste, for example, in the following manner. Initially, the paste is applied by screen printing or batch coating to form a coating layer having a predetermined thickness, the coating layer is dried, and a resist film is formed on the coating layer and is subjected to light exposure and development.